

Optical Free-Space Communication Activities at the German Aerospace Center's Institute of Communications and Navigation

... selected topics

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Knowledge for Tomorrow



Selection of Activities of DLR's Optical Communications Group

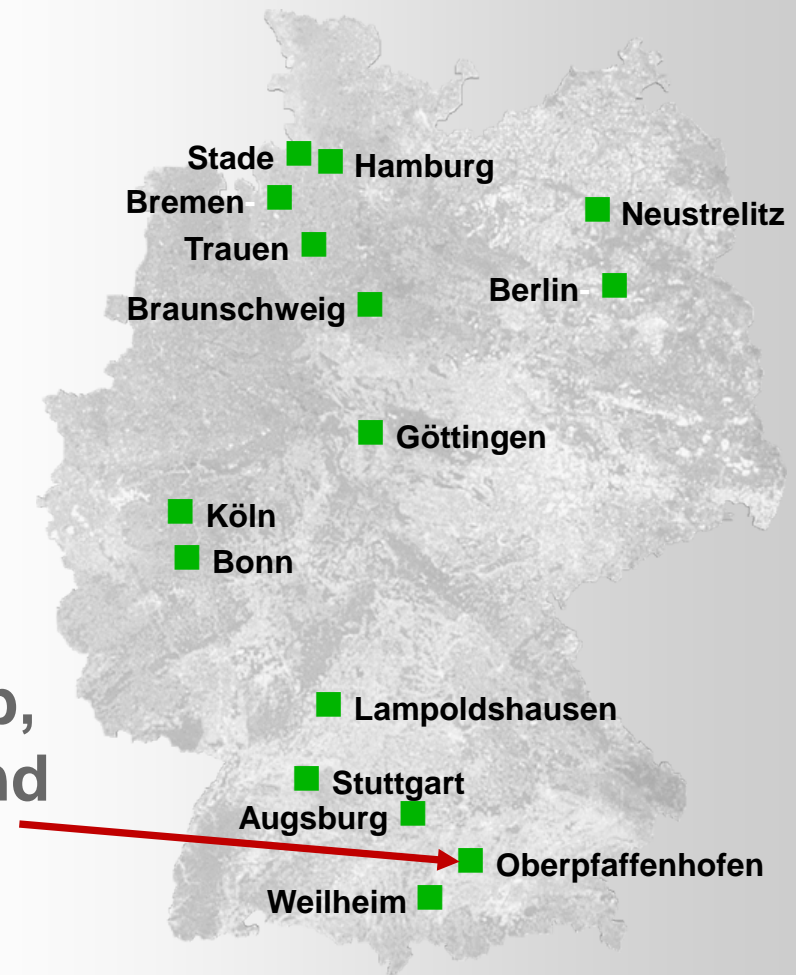
- OSIRIS – Small LEO Downlink Terminal**
- Aeronautical Downlink System**
- Optical Ground Stations**



DLR – the German Aerospace Center

DLR – Sites in Germany

**Optical Communications Group,
Institute of Communications and
Navigation**



Optical Communications Group

- Staff: 12 Scientists + PhD-Students
- Facilities: Optical Ground Station Oberpfaffenhofen (OGS-OP), Transportable Optical Ground Station (TOGS), Adaptive Optics Lab
- Experimental Projects: Aircraft Laser Terminal, Miniaturized Satellite Terminals (OSIRIS), Aircraft-Satellite Links, Atmospheric Index-of-Refractive Measurements
- Scientific Projects: Adaptive Optics for FSO, Frequency Dissemination through the Atmosphere, GEO Feeder Links, Electro-Optical Transceivers for FSO





OSIRIS – Laser Downlink Terminals for Small LEO Satellites

- 1) Open-loop pointing by satellite-bus' star tracker
- 2) Tracking sensor + Data uplink
- 3) Pointing unit



OSIRIS - Laser Sources

High Power Laser Diode (HPLD)

- Weight: ~150 g
- Up to 155 Mbit/s @ 0,1 W Optical Power
- Power Consumption: ~8 W



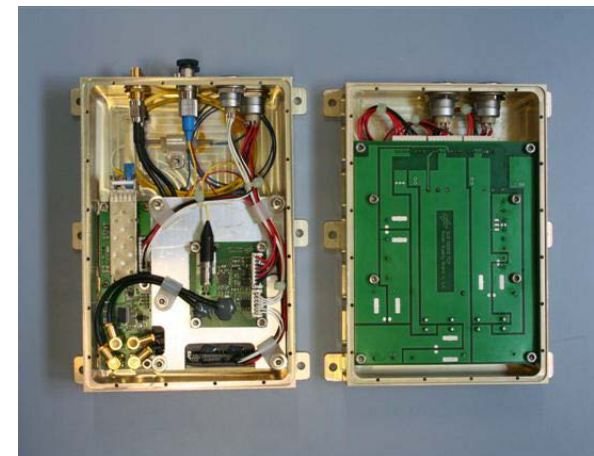
Erbium Doped Fiber-Amplifier (EDFA)

Weight: ~1 kg

Up to **2,5 Gbit/s** @ 1 W Optical Power

Power Consumption: ~35 W

Space-Qualification ongoing



OSIRIS - Tracking Devices

Tracking Device based on 4QD

Higher pointing accuracy

→ Better link-budget

Pointing done by satellite-bus

4QD: Four Quadrant Detector



Dedicated Pointing Unit

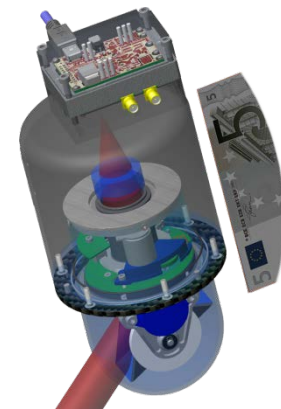
Pointing independent from satellite attitude

Goal:

„Coffee Cup“ sized optical comms terminal

< 5 kg

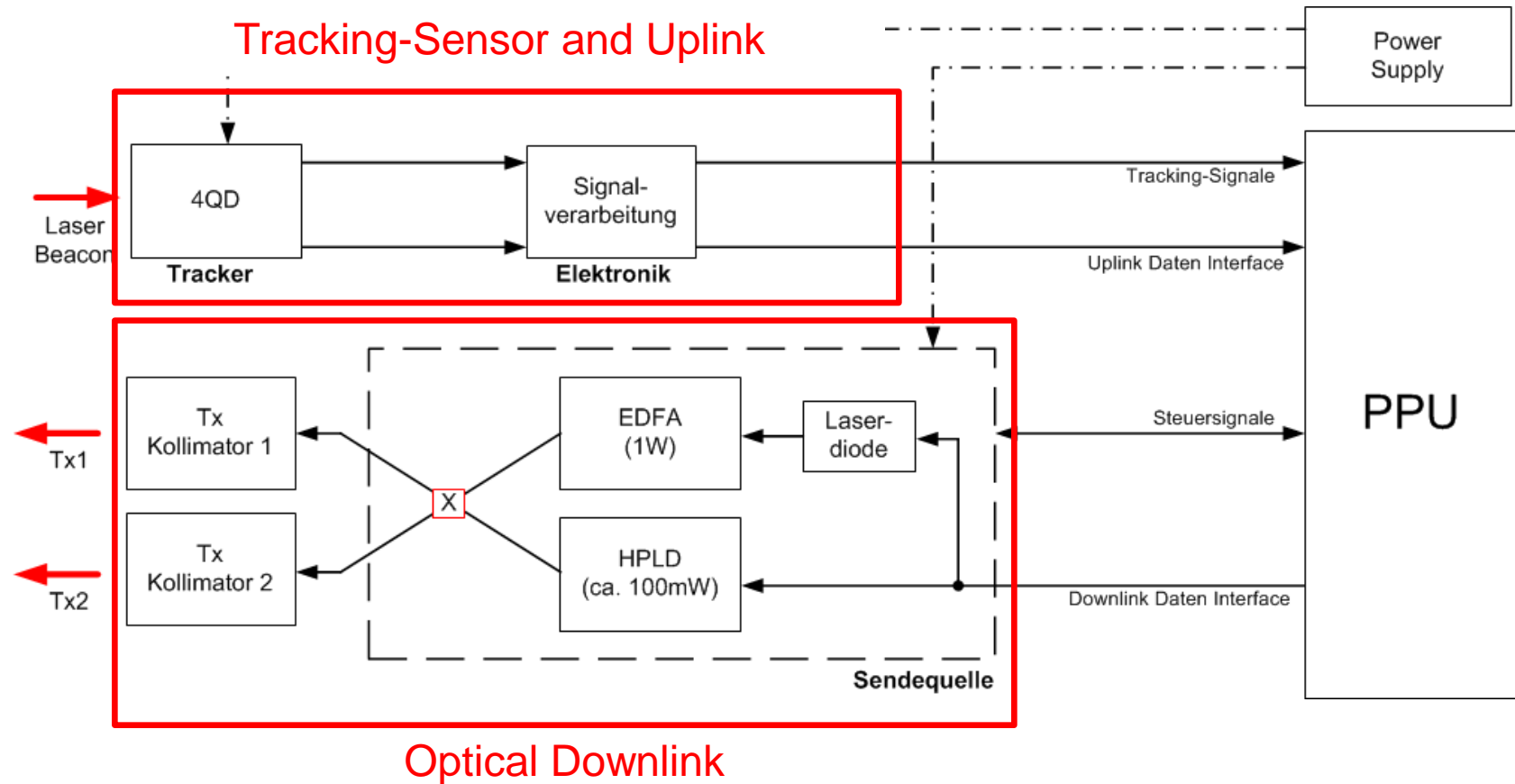
< 50 W (only during downlink)



Pointing Unit
for aeronautical applications



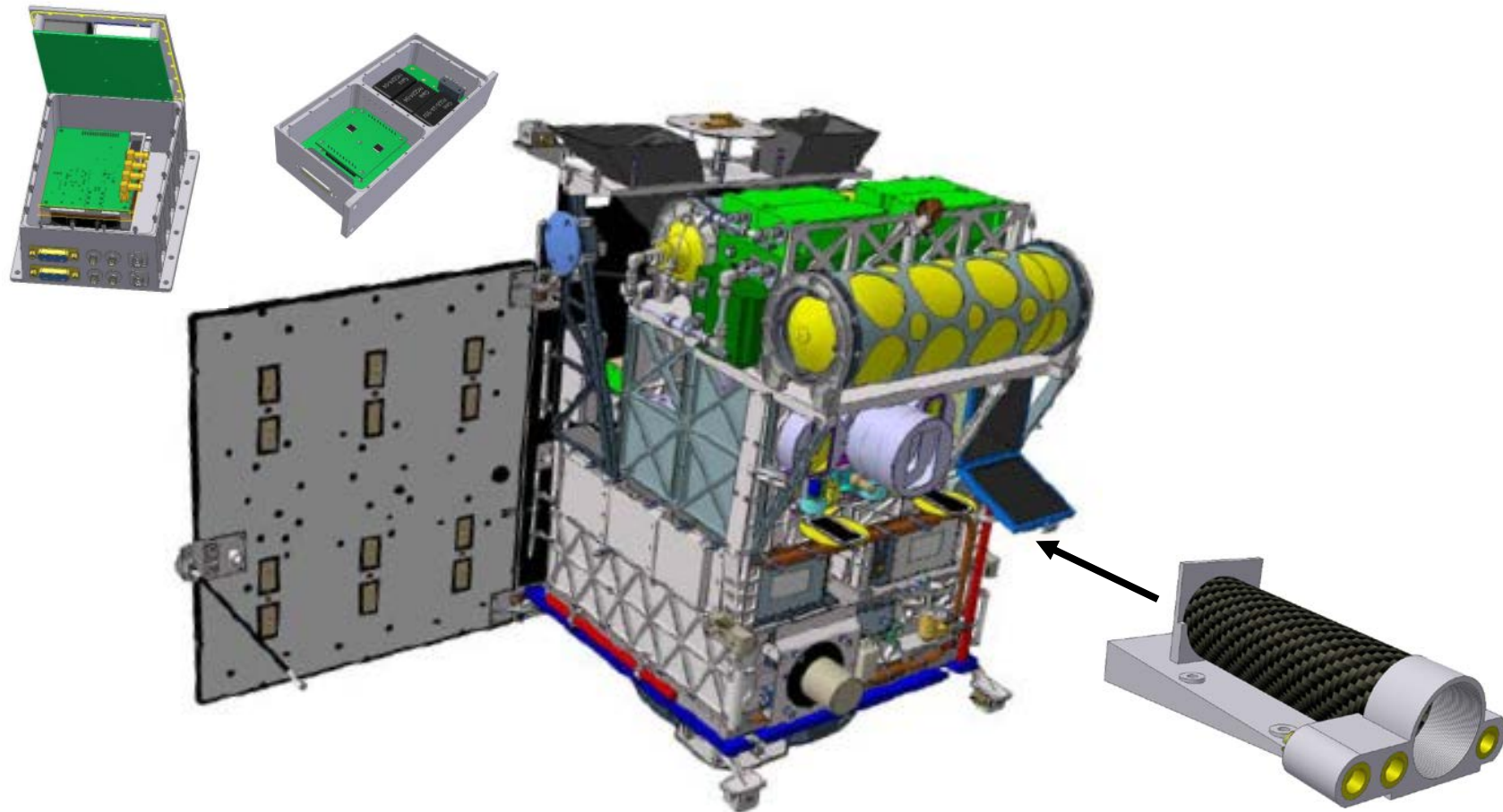
OSIRIS-Payload for *Biros* (incl. 4QD-Tracker)



PPU: Pre-Processing Unit



OSIRIS - Accommodation on BiROS

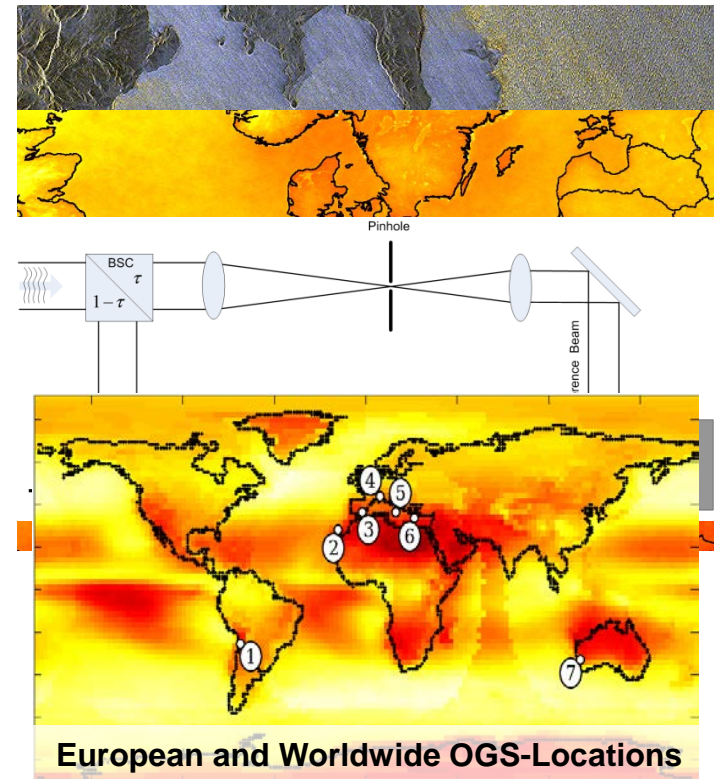


OSIRIS

Scientific Applications

- Feasibility of operational data downlinks with >1Gbps (space- and ground data handling)
- Verification of Ground Station Diversity Concepts
- Test Source for Adaptive Optics
- Downlink Channel Measurements at 1550nm

International cooperation is encouraged!



red/yellow: areas with low/high cloud probability

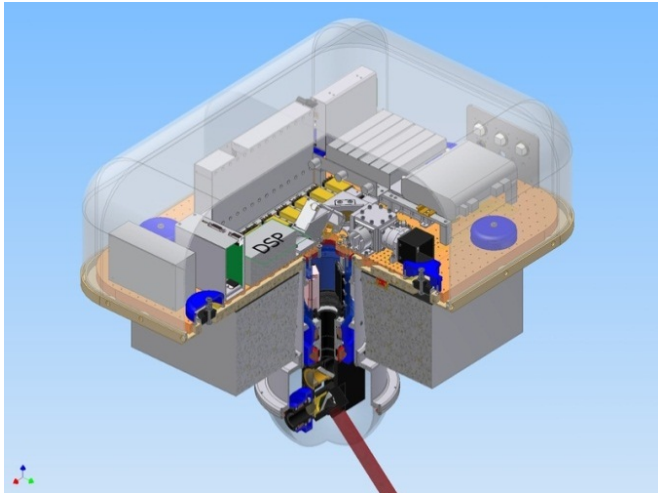




Aeronautic Downlinks



Aeronautic Data Downlinks at 1540/60nm IM/DD

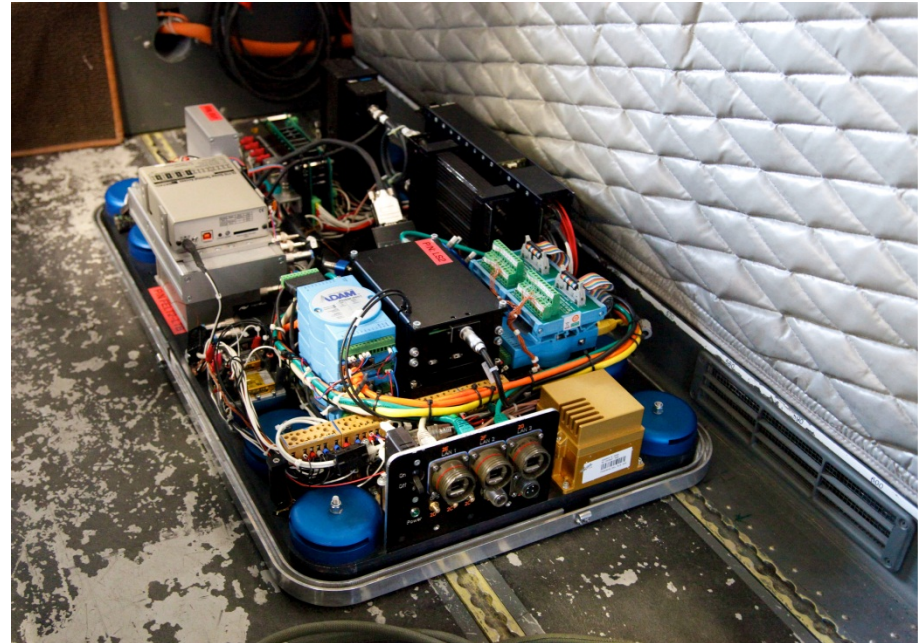


- Coarse pointing unit outside of aircraft
- Optical bench and electronics inside
- Bit-rates up to 1,25 Gbit/s
- Link distance up to 150km



Terminal-Details

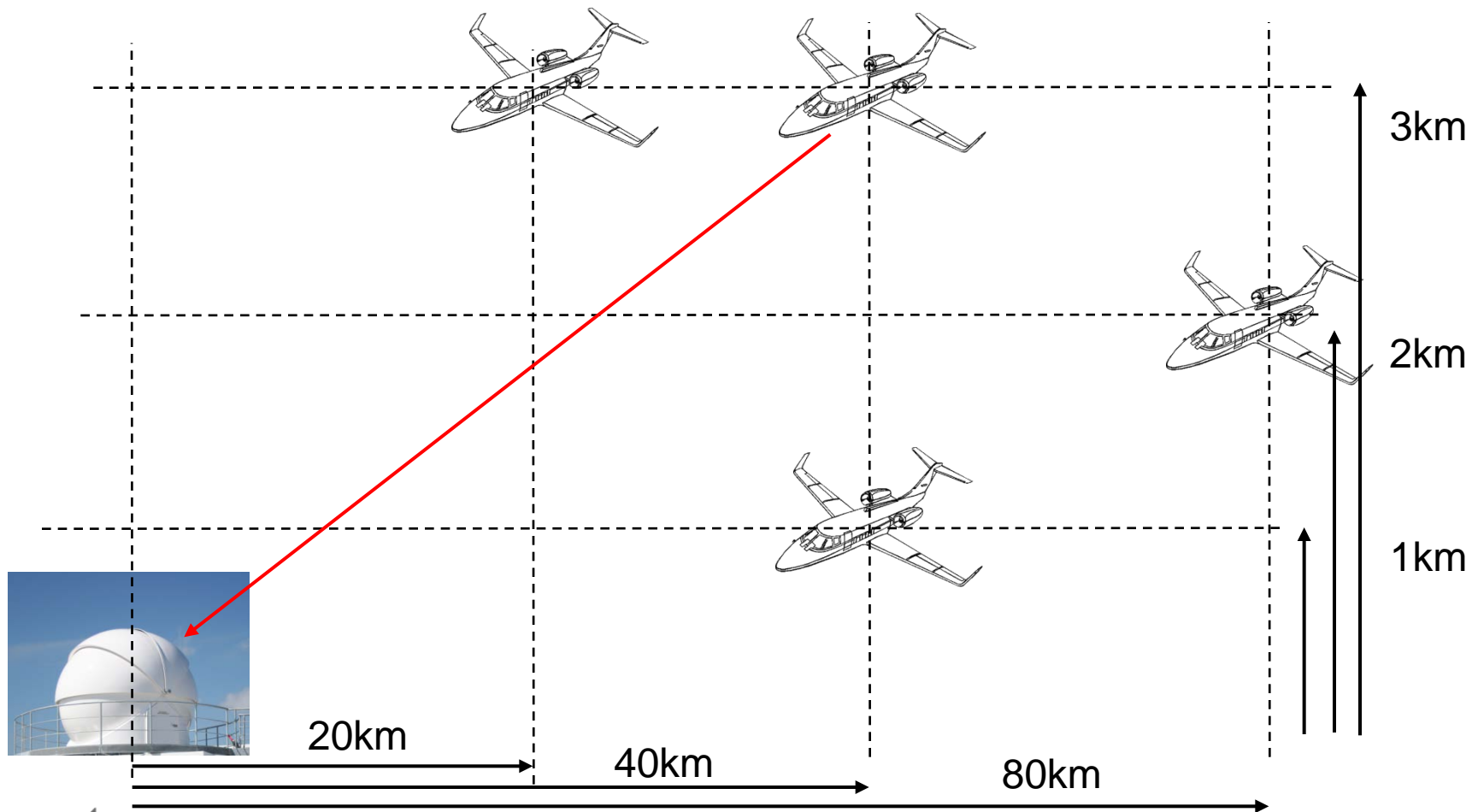
Control electronics and
tracking opto mechanics
inside the Dornier-228
experimental aircraft



Coarse Pointing
Assembly (30mm
aperture)

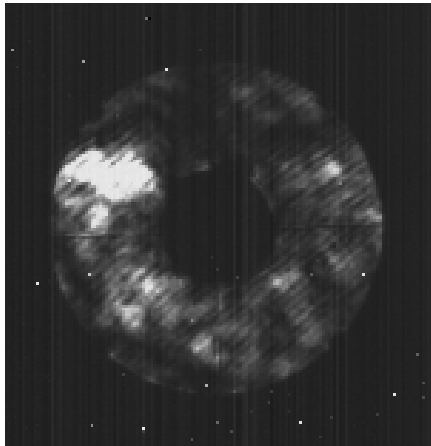


3D-Analysis of Atmospheric Turbulence Structure by Aircraft-Downlink

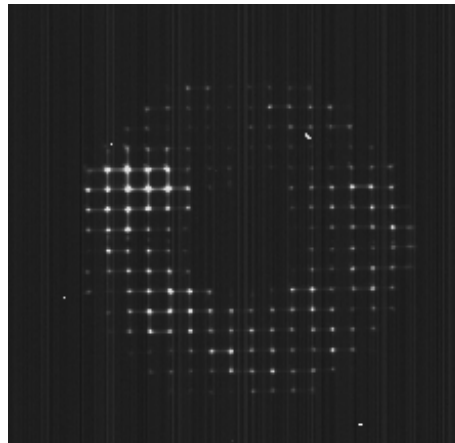


Synchronized Turbulence Measurement Devices → provides Complete Optical Field

Pupil



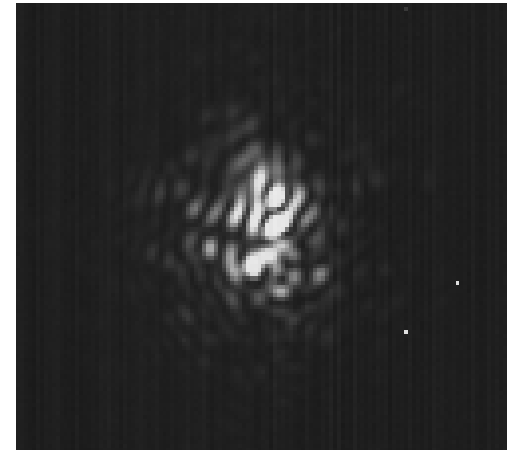
SHS → Phase



+

FFT
→

Focus



Capturing synchronized triggered and time-stamped
InGaAs-camera frames,
with Aircraft- and Satellite-Downlinks
at 1550nm / 1064nm



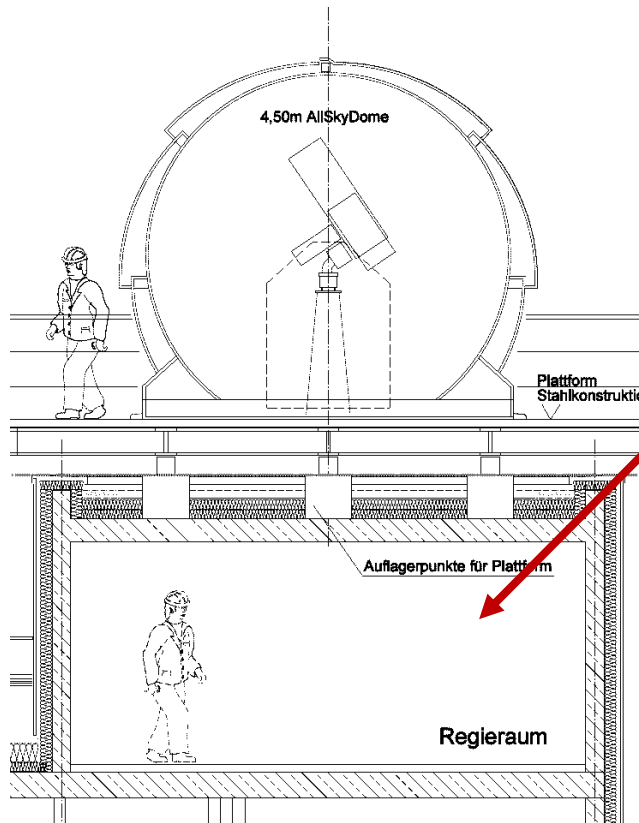


Optical Ground Stations



Optical Ground Station Oberpfaffenhofen / OGS-OP

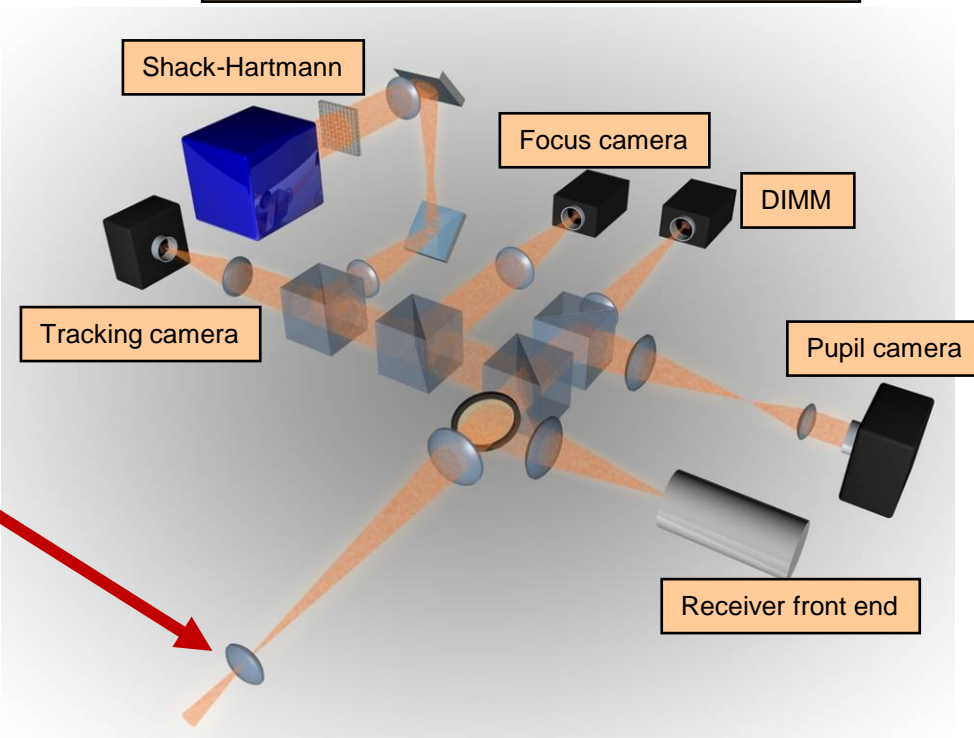
- 4,5m Clamshell-Dome on the institute's roof (20m above ground level)
- 40 cm Cassegrain-Telescope
- Operations- and Coudé-Room beneath



Turbulence Measurement Devices at OGS-OP



Optical system behind 40cm aperture



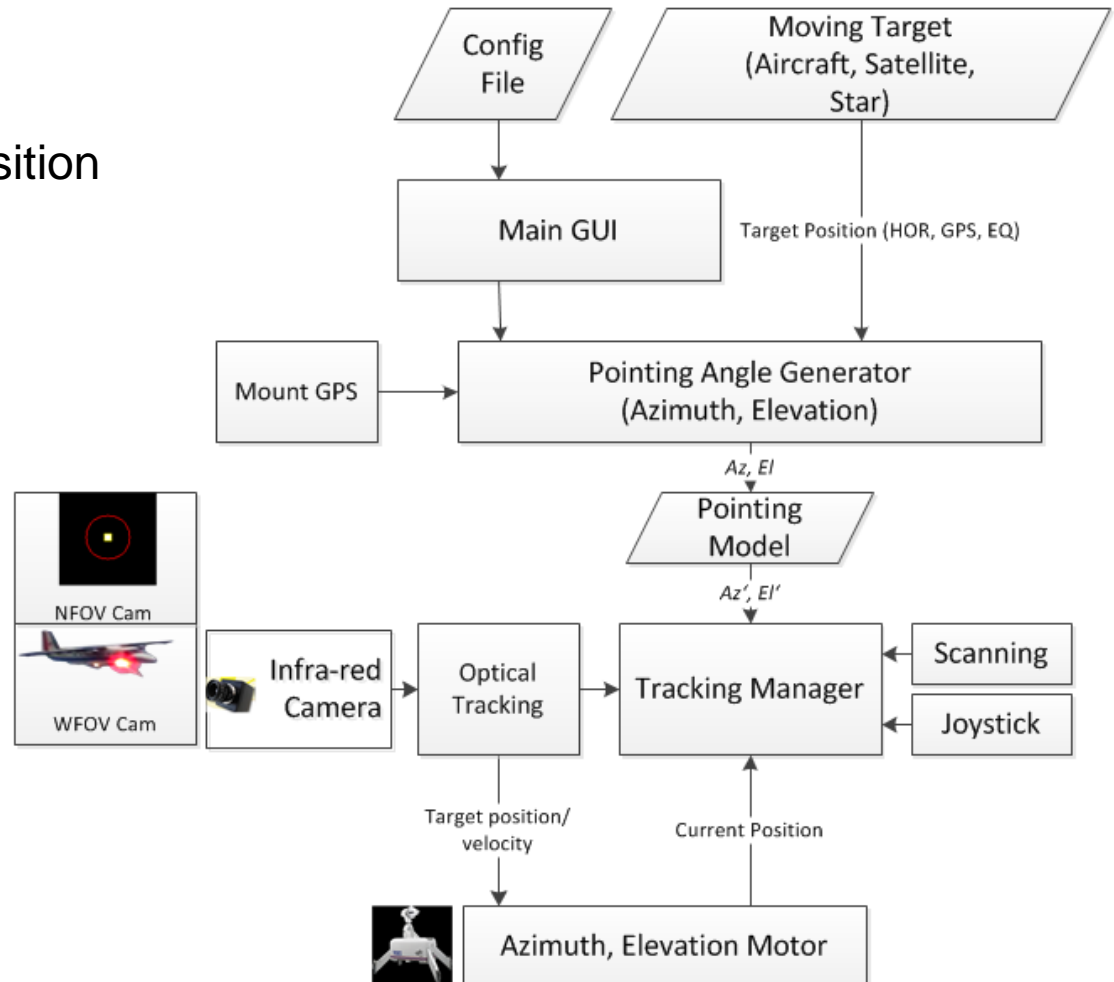
Transportable Optical Ground Station (TOGS)

- 60cm custom **Alumnium**-Mirror
- Drives developed by
DLR-Institute for Robotic and Mechatronic
- GPS-assisted Leveling
- Height >3m (→ eye-safety)
- Globally deployable
(size fits air-freight container)
- Optimized for Aircraft-
and LEO-Downlinks

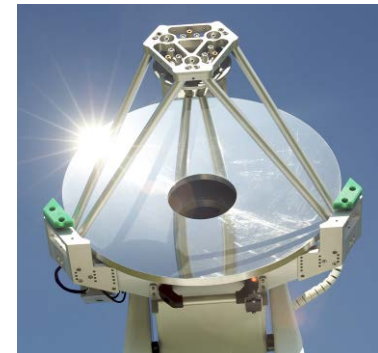


TOGS-Operation

- Calibration
- GPS- or orbit-assisted acquisition
- Beacon-control
- Wide-FoV-Cam
- Near-FoV-Tracking-Cam



Transport Van with Operations Rooms for TOGS



Other topics

- Adaptive-Optics for FSO under strong scintillation
- Frequency Dissemination through the Atmosphere
- Geostationary Optical Feeder Links
(Availability, Transmission Formats)
- High-Speed FPGA-based Data-Transceivers
- Quantum Key Distribution (demonstrated from Aircraft)



Thank You for Your Attention

Questions?



